

Review Paper ■

Rethinking Health Numeracy: A Multidisciplinary Literature Review

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Abstract The purpose of this review is to organize various published conceptions of health numeracy and to discuss how health numeracy contributes to the productive use of quantitative information for health. We define health numeracy as the individual-level skills needed to understand and use quantitative health information, including basic computation skills, ability to use information in documents and non-text formats such as graphs, and ability to communicate orally. We also identify two other factors affecting whether a consumer can use quantitative health information: design of documents and other information artifacts, and health-care providers' communication skills. We draw upon the distributed cognition perspective to argue that essential ingredients for the productive use of quantitative health information include not only health numeracy but also good provider communication skills, as well as documents and devices that are designed to enhance comprehension and cognition.

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Introduction

Much of the information provided to patients in written and electronic health communication is quantitative—information such as medication schedules, nutrition information, laboratory values, and risks and benefits of therapies. A growing literature attests to an awareness that many patients get lost in numbers, unable to fully comprehend or use this information. In this literature review, we examine the construct of *health numeracy* as studied in several disciplines, including consumer informatics and telemedicine,^{1,2} medical decision-making,^{3,4} psychology,^{5–7} health communication,^{8,9} health literacy,^{10,11} adult literacy,¹² and adult education.^{13,14} We also examine how health numeracy contributes to the appropriate use of quantitative information in health.

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Background

Just as health literacy has come to describe the use of literacy skills and health knowledge in health situations,^{15–17} health numeracy is emerging as an important concept describing the use of quantitative skills in health contexts.¹⁸ We adopt the definition provided in a recent short review: “the degree to which individuals have the capacity to access, process, interpret, communicate, and act on numerical, quantitative, graphical, biostatistical, and probabilistic health information needed to make effective health decisions.”¹⁸ Numeracy, as assessed by different measures, has been associated with outcomes such as poor anticoagulation control among patients taking anticoagulants¹⁹ and history of hospitalization in asthma.²⁰

However, our examination of the literature shows that the term “numeracy” has been used to describe several different specific skill sets. Some numeracy researchers have examined consumers' ability to manipulate percentages and proportions, while others have focused on ability to read appointment slips, communicate orally about medication schedules, or use tables and graphs. Furthermore, some studies focus on individual skills, while others focus primarily on effects of changing the numerical representation (for example, the design of a graph or the format of numbers). In addition, some numeracy-related articles discuss the skills of the health-care provider, not of the patient.

In this review, we organize these published conceptions of health numeracy and introduce the broader outcomes-oriented concept of *productive use of quantitative health information*, i.e., the effective use of quantitative information to guide health behavior and make health decisions. Productive information use (for example, a patient's successful completion of a medication regimen) depends only in part

on health numeracy, the individual-level skills to obtain, interpret, and process quantitative information as defined above. It also depends upon the ability of the expert or the information artifact to provide appropriate and cognitively manageable information. Even consumers with advanced math skills may perform poorly when trying to use poorly explained information; conversely, good design of information artifacts can compensate for weak individual-level skills. Thus, the productive use of the information can be considered a result of the entire system of health communication, not solely of the individual patient's skills.

We draw upon the distributed cognition approach, in which cognition is viewed not as a solitary endeavor but as a process of coordinating distributed internal representations (i.e., knowledge) and external representations (e.g., visual displays or patient education materials).^{21–26} In contrast to theories of individual cognition, distributed cognition emphasizes both the social nature of cognition (such as doctor-patient communication) and the mediating effects of technology or other artifacts (such as how written instructions or website design guide completion of a task). Distributed cognition suggests that productive health information use results from interplay between the quantitative competencies of the patient (health numeracy), the properties of the artifacts that mediate health cognition (information design), and the communication skills of the health-care provider.

Search Methods

We searched the MEDLINE, CINAHL, and PsycINFO databases using the keywords “health literacy” and “numeracy,” and drew upon a previously published systematic review of risk graphics.²⁷ We then used a “pearl-growing” strategy to seek additional publications through reference lists. We focused on research and clinical assessment instruments of quantitative skills among health consumers; studies of patient or consumer comprehension and decision-making; and major literacy surveys and researchers in adult literacy.

Review

As a first step to organizing this literature, we examined the range of meanings of “numeracy” by categorizing the underlying quantitative skills and characteristics captured in each study. We identified three categories of individual-level skills that have been studied among consumers: *basic quantitative skills*; *ability to use information artifacts* (for example, navigating documents); and *ability to communicate orally* about quantitative health information. These three constructs can be considered components of “health numeracy.”

Many of the numeracy-related studies we found, however, focused not on individual patients' competencies but on the format of the information presented to them. Thus, we created a fourth category for this literature review: *information design*, the systematic design of information (both symbolic representations of information and information channels) to improve comprehension and cognition.

In addition, some of the numeracy-related articles discussed or focused on the contribution made by the health-care provider or the information provider. Constructs included: *oral communication skills for health-care providers*; *basic quantitative skills among health-care providers*; and *providers' ability to use information artifacts*. As with patients, providers' ability

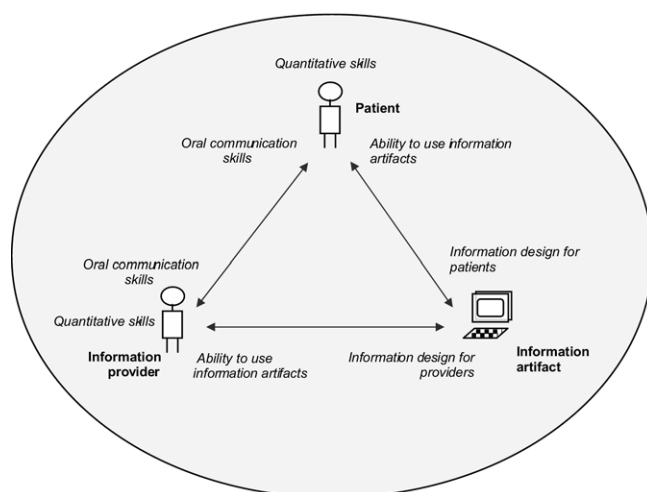


Figure 1. The successful use of quantitative health information requires basic quantitative skills on the part of the patient, but it also requires interactions with the person providing the information (who may be a doctor, a nurse, a counselor, or a friend or family member), and information artifacts (such as a written document, a website, or a medical device). Both the patient and the information provider must be able to manipulate and interpret quantitative information, as well as communicate about it. Both parties also need skills for interacting with information artifacts, such as document literacy and graphical literacy. Individual quantitative skills and artifact-interaction skills are both strongly affected by the quality of information design; good design can ease cognitive burden and improve comprehension.

to use information artifacts is inextricably linked to *information design*.

In this review, we focus primarily on the factors of greatest interest to consumer informatics: patients' quantitative skills, patients' ability to use information artifacts, and information design for patients. However, we believe that productive use of quantitative information for health requires a health communication system that considers all eight of these factors (Figure 1, Table 1).

Patients' Quantitative Skills

Much of the research on patients and quantitative information has addressed individual-level competencies. We group the individual-level competencies into three categories: 1) basic computation, 2) estimation, and 3) statistical literacy.

Basic Computation

Basic computation encompasses number recognition and comparisons, arithmetic, and the use of simple formulas. The TOFHLA¹⁰ screening test for comprehension of written health information assesses these skills with questions such as computing times for taking a pill, comparing a blood sugar level to a standard to decide whether it is abnormal, and interpreting an appointment slip. In the validation sample, of whom 31% had education beyond high school, only 25% answered all four numeracy questions correctly.²⁸ A four-item instrument validated among patients with asthma includes asthma-specific computations of medication dosages and percentage of peak flow.¹⁹ A broader view of computational numeracy is provided by the national and international adult literacy surveys.^{12,29,30} These surveys

Table 1 ■ Factors Contributing to a Patient's Ability to Use Quantitative Information for Health

Factor	Definition	Examples
Patients' quantitative skills	basic computational skills (such as addition, multiplication, and use of simple formulas), estimation, and statistical literacy	computing calorie content; comparing computation to estimate to determine whether it is correct; understanding concept of randomization in a clinical trial
Patients' ability to use information artifacts	ability to navigate documents, interpret graphs, and translate between different representations of the same information	obtaining nutrient information from a nutrition label; comparing personal health data as displayed on different meters or devices
Patients' oral communication skills	ability to speak clearly about quantities and understand spoken information	reporting a previous medication regimen accurately to a new physician
Information design for patients	arrangement of information media and symbols to support comprehension and cognition	designing a patient interface for an electronic health record that provides graphics to illustrate numerical information
Providers' oral communication skills	ability to communicate quantitative concepts clearly to the patient	explaining a new medication regimen to a patient in an understandable fashion
Providers' quantitative skills	basic computational skills, estimation, and statistical literacy	converting between units of measure; understanding the positive predictive power of a diagnostic test
Providers' ability to use information artifacts	ability to navigate documents, interpret graphs, translate between representations of the same information	interpreting a graph of patient lab values over time; applying the numerical output of a decision support system to an individual case
Information design for providers	ability of a system or document to support the provider's cognition	designing a provider interface that provides automated conversions between units of measure

include a variety of quantitative problems, rated simple if they are familiar and well-defined (e.g., adding numbers on a bank deposit slip), or complex if they require using abstract information to solve multi-step problems. An example is a problem with cryptic price labels ("rich chunky pnt bt" for "chunky peanut butter") in dollars per pound; respondents must calculate price per ounce.¹²

One type of computational skill that has been widely studied in health contexts is the ability to manipulate percentages and probabilities, because risks are often represented as percentages (e.g., 15%), proportions (0.15), or frequencies (15 in 100). Many patients lack basic probability skills, according to results from several studies using related screening measures.^{3-5,19,31,32} These tools (ranging in length from 3 to 18 items) assess the ability to state the numerical probability of heads in a coin toss and the ability to convert between percentages and integers. In validation on a highly educated sample, only 32% got all questions correct, and 16%-20% were unable to answer questions such as "Which represents the larger risk: 1%, 5%, or 10%?"³¹ An understanding of probabilities is required for the standard gamble method of utility elicitation, in which subjects are asked to choose between a health state and a specific probability of death.³³ Logical inconsistencies are more common with standard gambles than with visual analog scales, and lower educational level is associated with errors with standard gambles.³³ Subjects also tend to rate standard gambles as more difficult to use than visual analog scales.³³ In two studies, poor probability reasoning was associated with standard gamble inconsistencies.^{34,35}

An entire body of work discusses the relationship between the analytic use of quantitative probability information and the affective feeling of risk.^{5,7,36} In brief, a variety of circumstances including stress and time pressures can cause people

to base decisions on rapid and automatic affective responses rather than the more effortful analytic assessment of quantitative information.

Estimation

Adult education theorists point out that people perform precise calculations only in certain situations, such as completing financial forms, which have been termed *generative situations*.¹³ However, people solve many real-world problems not by calculating but by estimating or using number sense (a basic feel for magnitudes and operations).³⁷ Applying an estimation heuristic is generally quicker and simpler than calculating and is often sufficient for *decision situations* (e.g., choosing groceries while meeting a budget).¹³ Estimates may also help in *interpretive situations*¹³ such as reading a news article, as well as in judging the probable correctness of a calculation. As many health situations involve interpreting quantitative information or making decisions, these examples from the adult education literature suggest that the role of estimation in health contexts warrants further study.

Statistical Literacy

Statistical literacy is an understanding of concepts such as chance and uncertainty,³¹ sampling variability, margins of error, and randomization in clinical trials,¹⁸ and the ability to use such concepts to evaluate scientific information.³⁸ It is thus strongly determined by domain knowledge as well as by procedural skills. The measures of probability reasoning discussed above, including the medical data interpretation test, capture elements of statistical literacy such as the concepts of uncertainty and chance.^{3-5,19,31,32} Statistical understanding can help patients in specific decision situations such as granting informed consent to be in a research study. It can also help consumers understand epidemiological

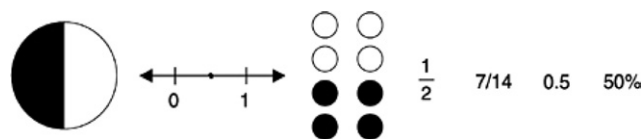


Figure 2. The quantity $1/2$ may be represented in a variety of logically equivalent but cognitively different ways. Reprinted from ⁴³ p. 101. With permission.

information and how it is applicable to personal health or to public policy. Statistical literacy might also promote trust in the information. Lower educational level has been linked to poor understanding of the concept of scientific uncertainty and distrust of information presented as uncertain.^{39,40} People with low statistical literacy may be vulnerable to anti-scientific messages such as exaggerated warnings about vaccine risks. A comprehensive assessment of statistical literacy and its relevance to health decisions would be valuable.

Patients' Ability to Use Information Artifacts

Before patients can compute, estimate, or interpret data, they must acquire it, often from documents, scales, or other information artifacts. Three interrelated skills (representational fluency, document literacy, and graphical literacy) have been described as necessary for using information artifacts.

Representational Fluency

Representational fluency is the ability to translate between and recognize the identity of different representations of the same quantity.^{1,2} For example, the quantity "one-half" can be represented as a fraction, a decimal, or a picture (Figure 2); some representations are more useful for problem-solving than others. Translating between representations is an important mathematical problem-solving skill⁴¹ and cognitive milestone in children.^{42,43} Mappings between representations and concepts are not inherent but are established through learned cultural conventions.⁴³ Medicine, like other complex domains, introduces new representations that can challenge newcomers, such as patients or medical students.

Representational fluency may underlie several other computational skills. Subjects with poor probability reasoning were likely to make different decisions when numbers were presented in different formats (10 in 100 versus 10%), apparently because they were less able to translate between representations of the same quantity.⁵ Poor probability reasoning was also associated with greater susceptibility to framing effects, probably for the same reason.⁵

Representational fluency is particularly relevant to the ability to use personal health care technologies and measurement tools such as meters, which represent information in unfamiliar formats. In a diabetes telehealth program for elderly patients,^{1,2} lack of representational fluency made it difficult for some participants to review their glucose and blood pressure values when they switched technologies. These patients, who could readily read their blood pressure from a meter, were not able to recognize the tabular representations of the values. Some seemed unfamiliar with the conventions of columns and rows (see 'document literacy,' below), and they may have been unable to equate blood pressure shown as 120/90 with the same value shown as

(Figure 3). Some people who had kept glucose logs on paper for years could not use the tables.^{1,2} Similar issues are likely to arise with electronic personal health records.⁴⁴

Document Literacy

Quantitative information is often provided in the form of a complex print or electronic document that combines text with lists, forms, or tables. Before applying any procedural skills, such as computation, the patient must be able to navigate and interpret these documents. Among adult literacy researchers, the ability to use information embedded in complex text and non-text formats is called document literacy.²⁹ In the National Adult Literacy Survey (NALS), 23% of the public received the lowest score on document literacy, indicating they would have difficulty performing tasks such as completing forms or using information in tables.¹² In the Health And Literacy Scale (HALS) analysis, health literacy was worst among those with poor document literacy.¹⁶ Document literacy includes the abilities to complete multi-step calculation problems and to infer the right mathematical operation when it is not provided. One HALS question¹⁶ showed a medication label; although calculating the correct dose was arithmetically simple, the task also required deciding on the algorithm (not provided), locating numbers in the table, and separating relevant from irrelevant information. Eisemon et al. provide an example of a medication that had to be mixed with water; the instructions explained how to calculate the dose, but a different calculation (not provided) was needed to determine how many packets of powder to purchase.⁴⁵ In a study of nutrition label interpretation, only about 28% of the errors were inaccurate calculations; the remaining errors stemmed from an inability to exclude extraneous or complex information, or wrong application of serving size/servings per container information.⁴⁶

Graphical Literacy

The ability to interpret quantitative graphics helps people use educational materials, news reports, and electronic systems. Graphics are valuable in illustrating consumer informatics applications,^{47,48} and visual analog scales may be more intuitive than standard gambles in utility elicitation.³³ However, many people have difficulty interpreting graphics that are not familiar.^{27,49–53} For example, in a sample drawn from a jury pool, 23% could not use a survival curve to determine the number of survivors at specific times, and 45% could not calculate the difference in survival between two times.⁵¹ Although these examples show that graphical literacy has been studied in a variety of settings, it is not assessed by any health literacy instrument.

Information Design for Patients

The ability to apply basic computational skills is strongly influenced by how the information is represented in a questionnaire, document, graphic, or medical device. Including information design in a discussion of numeracy shifts the focus, to some extent, from the patient to the representations in the artifact. Even readers with strong literacy skills can have difficulty using quantitative information presented in complex formats such as nutrition labels, and those with poorer literacy have more trouble.⁴⁶ For nutrition labels, Rothman et al. recommend information design improvements such as presenting nutrient totals for the entire package, removing extraneous information, and

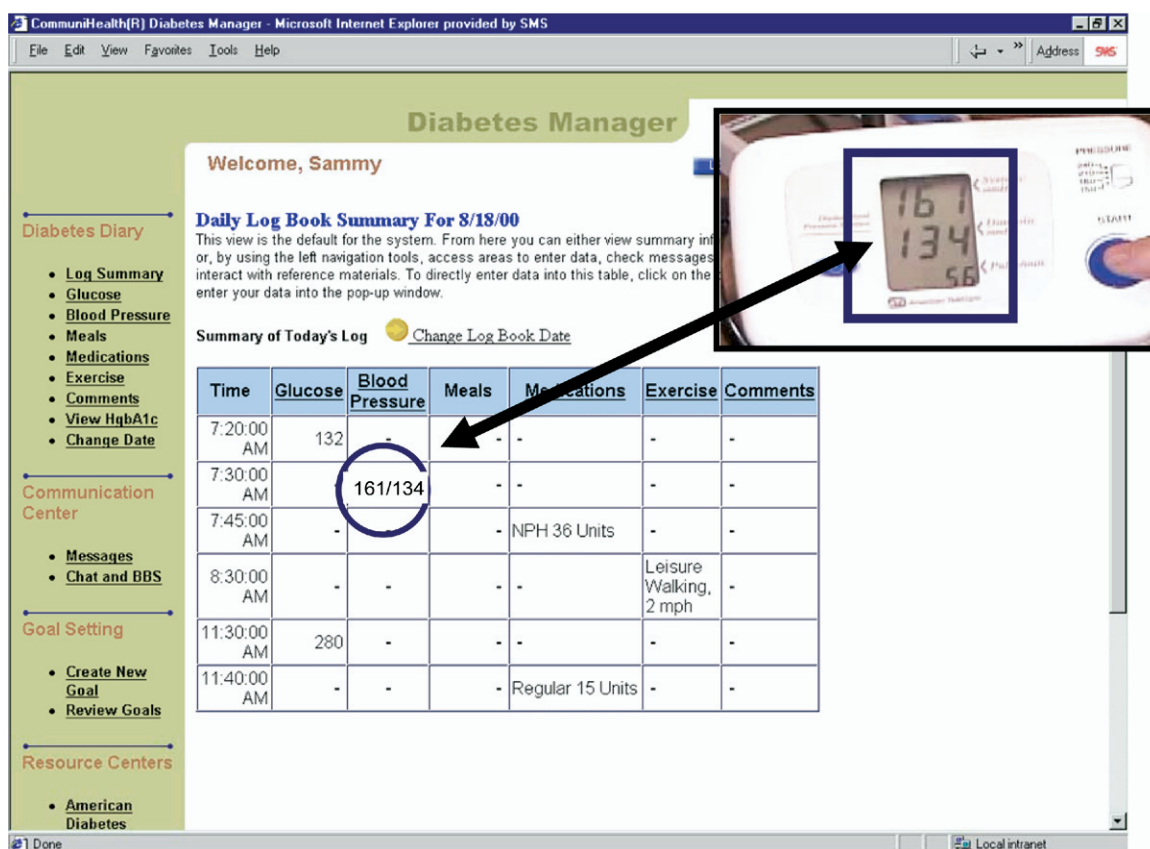


Figure 3. Systolic and diastolic blood pressure displayed in a computer-generated table as part of the IDEATel^{1,2} telehealth program, and (inset) on the blood pressure meter. Some elderly participants who had no difficulty reading the values on the meter were unable to understand the same information displayed in the table.

adding visual cues (such as lines on an ice-cream container) to indicate serving sizes.⁴⁶

The framing effect is another example of a representation effect;⁵⁴ framing effects are nearly universal but they are strongest among people with poor probability reasoning skills.⁵ Numerical format effects are also strong: in a study of patients in a clinic waiting room, only 73% could tell that a disease affecting "2.6 per 1000 women" was less common than one affecting "8.9 per 1000 women," and when the same comparison was presented as "1 in 384 women" and "1 in 112 women," only 56% answered correctly.⁵⁵ Evidence conflicts about whether percentages such as 46% or frequencies such as 46 in 100 are easier to understand.^{56,57} Another representation effect is the relative comparison effect: relative differences without absolute risks for context inflates the apparent magnitude of the effect.⁵⁸⁻⁶⁰ That is, an increase from 1% to 2% seems larger when it is described as a 100% (relative) increase than when it is described as a 1% (absolute) increase. Adding baseline risk to either absolute risk reductions or relative ones strongly improves the accuracy of interpretation of risk reduction information.⁶¹

Poor representational fluency can be addressed by providing quantitative information in multiple formats (that is, in proportions as well as frequencies, or in text as well as graphics). Supplementing text with graphics can reduce the influence of less-relevant textual information to promote better decision-making⁶² and improve accuracy in comparing probabilities.⁵⁶ By contrast, when people are asked to

think of themselves in unfamiliar health situations, supplementing dry textual and numeric information with anecdotes may improve decision-making by helping readers imagine the situation more clearly.⁶³ Providing multiple formats may also help reach a broader audience; highly numerate lay people preferred risk information in numbers instead of in words alone, while those with poor numeracy skills did not.⁶⁴ There is some evidence that presenting information in both gain and loss frames may reduce framing effects.⁵⁰ Completing calculations for the consumer reduces the cognitive effort required to process probability information and improves accuracy in making risk tradeoffs.⁵⁶ For example, instead of merely stating that a drug will triple the risk of some bad outcome, the communication can present the baseline risk of 4% and the end risk of 12%, and instead of expecting consumers to add the risks of two separate outcomes to decide about the overall usefulness of the drug, the communication can provide the total summed risk for both the outcomes.⁵⁶

Designing graphs to support patient cognition is challenging, in part because users often prefer design features such as visual simplicity and familiarity that are not necessarily associated with accurate judgments.²⁷ Patients prefer graphics supplemented with text⁶⁵ probably because explanations help them draw conclusions. Risk graphs such as bar charts can show the numerator only (e.g., a bar 10 units high depicting a risk of 10%), or they can display the part-to-whole relationship between the

numerator and denominator of the risk ratio (e.g., by showing the risk of 10% as one-tenth of a larger bar depicting 100%). Graphs that depict numerators alone emphasize the risks and are more likely to promote risk-related behavior changes, while graphs that depict numerators in context of denominators promote accurate judgments.^{6,66,67}

One informatics application that works in part by easing document literacy burdens is tailoring information so it contains only personally relevant facts.⁶⁸ Well-designed electronic and print decision aids can also reduce document literacy demands by presenting personally tailored information in manageable chunks. Their measured benefits include increased knowledge, more realistic expectations, and better agreement between choices and expressed values,⁶⁹ all of which might reflect better understanding of the quantitative risk information.

Other applications that may help are those designed to promote active information-processing. For example, writing answers to reflective questions and drawing graphs improves comprehension of and satisfaction with risk information.⁷⁰ It is possible that electronic health and medical information systems could improve comprehension by inviting the patient to engage in active information processing by completing self-tests or interacting with the system in other ways. In an ongoing project, we are assessing a risk communication module that allows users not only to input personal risk characteristics and receive a graphic illustration of their risk, but also play with the graphic in a game-like interaction; for example, for a disease risk of 10%, the user can click on stick figure illustrations and see that 10% of them will contract the disease.⁷¹ Technology can also be designed to facilitate distributed cognition through collaborative learning and problem-solving: in the IDEATel project,^{1,2} the nurse and the patient could simultaneously view tables and charts of the patient's data during a video-conference, with discussions to facilitate patients' understanding of key concepts such as HbA1c level, an important determinant of health in diabetes patients.

Oral Communication Skills among Providers and Patients

The focus of this article is on patients' quantitative skills, their interaction with information artifacts, and the design of these artifacts. However, it is important to acknowledge that consumers and patients obtain much of their information, particularly their personal clinical information, through oral discussions. They listen to instructions, quantify their experiences, express utilities and preferences, and ask questions. For example, physicians rely upon patient report of frequency, duration, and severity of symptoms, and, often, of their medication regimens.⁹ When cognition is seen as distributed among social agents,²⁵ it is clear that quantitative problems are often solved during interactions, as when a physical therapist and a patient discuss scheduling exercise sessions, or a married couple complete a health insurance form together. Content analysis of audiotaped consultations shows that physicians vary in oral communication style, and may omit numerical information or fail to assess patients' understanding of it.^{72,73} Risk communication training has been developed for physicians and public health professionals,⁷⁴ but not assessments of professionals' ability to explain

numerical information in general. Patients cannot use quantitative information well if their providers do not explain it clearly or are not attuned to the kinds of communication most likely to be understood by a particular patient.

Quantitative Skills of Health Care Providers

The individual providing the information (physician, nurse, public health worker, journalist, or other information provider) must also have skills in basic computation, estimation, and statistical literacy. Brief reports have indicated that many medical students⁷⁵ and health care professionals³² perform poorly on numeracy assessments focusing on risk and probability. Such skills are obviously important for basic care issues such as calculating doses, converting units of measure, and interpreting clinical data, but they are also important for communicating with patients. An example illustrates the role of professional numeracy in health communication: in one report, physicians and social workers giving HIV counseling at German clinics became confused when asked about false positives, false negatives, and predictive power.⁷⁶ Patients are unlikely to use information well if their providers do not understand it themselves.

Providers' Ability to Use Information Artifacts

To provide patients with useful quantitative information, the health care provider must be able to obtain it from journal articles, information systems, medical devices, or other information artifacts. An important focus of the evidence-based medicine movement has been to train physicians to use journal articles, appraise them with a critical eye, and especially to extract and interpret relevant statistical and other numerical information.⁷⁷ Lack of training in the use of statistical information has been identified as an important barrier to use of decision-support systems: a web-based tutorial improved adoption of a decision-support system for acute cardiac ischemia by teaching clinicians how to combine the population-based risk score output by the system with patient-specific data.⁷⁸

Information Design for Health Care Providers

Information artifacts must be designed to support health care providers' cognition about numbers, particularly to enable them to discuss information clearly with patients and the public. A full discussion is beyond the scope of this paper, but some examples demonstrate the importance of this design issue. Adverse drug events associated with incorrect doses and administration rates have been associated with poor design of human-computer interfaces in patient-controlled analgesia devices.⁷⁹ Physicians are also subject to judgment biases from framing⁵⁴ and the format of numbers and graphs. In one study, physicians rated drug effectiveness on an 11-point scale. Perceived effects were larger when described as relative differences (e.g., a relative decrease of 36%) than when described as absolute differences (e.g., an absolute decrease of 1.4%, from 3.9% to 2.5%).⁵⁹ In a second study, physicians were more likely to answer computational problems about positive predictive power correctly when probabilities were formatted as "natural frequencies" (ratios with the same denominator, such as 10 in 100 and 20 in 100) than as percentages.⁵⁷ In a simulated patient-safety review experiment, Elting et al. tested the use of different representations of data from a hypothetical clinical trial showing a strong association between one of the treatments and an adverse outcome.⁸⁰ One representation

was a stacked bar chart, two were tables, and the last was a group of squares, with each square representing an individual subject, colored to indicate his or her outcome. Physicians were more likely to order a halt to the trial when viewing the tables or the groups of colored squares than when viewing the stacked bar charts.⁸⁰ Such information design effects influence providers' competency with quantitative information, and, indirectly, their communication of quantitative information to patients.

Discussion

Consumers' ability to use quantitative information to guide their health behavior and health decisions requires more than the ability to perform computations. Consider the example of a woman who seeks to lose weight. She may obtain information by reading articles in popular magazines, doing Internet research, talking with friends or a support group, or discussing her goals with a nurse. If she decides to begin walking for exercise, a variety of external resources for information seeking and processing are available: she can use her car odometer to measure distances, look up calories per mile walked in a table, and use a calculator to calculate total calories expended. If she decides to adopt a healthier diet, she can seek nutrition information on food labels and use it for calculations, estimates, or comparison with a threshold (she can, for example, decide to avoid products with more than a certain percentage of calories from fat). She can use a measuring cup to measure servings of breakfast cereal, or learn to estimate the amount. She may also weigh herself on a bathroom scale, use a diary to track weight or exercise accomplishments over time, and share information with friends or supporters.

As a second example, consider the case of a man seeking treatment for prostate cancer. Initial information is likely to be explained orally by a physician, who may or may not be skillful at explaining laboratory and biopsy results and each treatment option's chance of success and risk of adverse effects. The patient may work with his wife to use a decision aid, find additional information online, or e-mail the physician. The couple may both attend the next appointment, perhaps bringing simple memory aids such as a printout or a list of handwritten questions, and seek help interpreting information through additional conversations with the physician or nurse. The final decision is likely to be made in collaboration with the doctor.

These examples suggest that the use of quantitative information for health is often highly situated, distributed across internal and external resources, and collaborative, as suggested by theories of distributed cognition. Patients and health consumers may obtain quantitative information orally as well as through printed and electronic material, and from devices such as bathroom scales. This information may be used to make calculations, decisions, or estimates. Consumers extend their memories by putting health information in writing or computers. They reduce cognitive effort and augment personal skills by offloading computations onto external resources such as calculators or paper. They frequently rely on social interactions to help derive meaning from quantitative information and make decisions from it. The representation of the information strongly affects individual cognition; better external resources can compensate for weak individ-

ual-level skill sets, while poor external resources require more skilled individual cognition. As characterized by a distributed cognition framework, productive use of quantitative information in health requires individual skills (health numeracy) but is also mediated by social interaction and artifacts.

Conclusion

In this review, we organize research on health numeracy, defined as the individual-level skills to obtain, interpret, and process quantitative information for health behavior and decisions. We find that the term health numeracy has been used to describe a number of different types of individual-level competencies, including basic arithmetic operations on health-related data, facility with probabilities, and statistical literacy. Other individual-level skills sometimes discussed in connection with health numeracy include oral fluency and ability to navigate documents, tables, and graphs, but no available instrument for health numeracy assesses all these component skills. We also find that the ability to use quantitative information is strongly influenced by two other factors: design of information artifacts, and providers' communication skills. Although tools are available for assessing the 'readability' level of documents,¹⁵ there are no similar tools that characterize their quantitative demands. Similarly, instruments are available to assess aspects of numeracy in patients, but no assessments have been developed to evaluate providers' ability to provide comprehensible information about numbers.

In 2000, health literacy was described as the skills needed to "obtain, process, and understand basic health information and services for appropriate health decisions."⁸¹ Subsequent commentaries pointed out that this definition focused on the individual patient's skills without recognizing the complementary importance of good communication skills by health experts or the complexity of written information.^{17,82} We similarly argue that discussions of quantitative information in health should be expanded beyond a focus on the skills of the patient. Poor use of quantitative information may stem from poor individual-level skills, but it may also be the result of mismatch between the patient's skills and the provider's communication skills or the artifact's information design (Figure 1). Baker has made a similar argument about health literacy.⁸²

This topic is important because the amount of quantitative information for patients is growing rapidly, largely through the internet and health information technologies. Although this information explosion promises to empower many patients, it also has the potential to exacerbate the literacy divide for those who lack numeracy, literacy, or computer skills. Our framework suggests that the divide can be narrowed by educating not only patients but also information providers. Furthermore, by enhancing the design of health-related systems and documents, the informatics community can help improve the fit between task demands and individual competencies, helping consumers use quantitative information to make genuinely informed decisions about health.

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